LETTERS TO THE EDITOR.

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Organisation of Scientific Work.

I TRUST the rank and file of scientific investigators throughout the Empire will wake up to the urgent need of combined energetic action. The proposals to centralise under the control of a few official departmental heads the body of actual scientific investigators in India, thus creating a few highly paid administrative posts for senior men and effectually killing all initiative, enthusiasm, and liberty of action on the part of those actually carrying on the investigations, is perfectly in accord with what has happened in this country since, in an evil day, the Government assumed the control of scientific and industrial research. It is a proposal that appeals, naturally, to the official without knowledge of the way in which scientific discoveries originate, and anxious to secure a body of cheap and docile labour, even though it be mediocre in calibre, and to those few who hope to secure for themselves these senior lucrative administrative posts. To genuine investigators such posts, however highly paid, would be unattractive, and under such a system there seems every inducement for men of originality and scientific ability to give the service a wide berth. Whereas the crying need in India, as everywhere, is for men of high calibre and honest, independent mental outlook, anxious only to secure favourable conditions under which they may be left free to pursue their creative work, and, this being secured, careless of wealth, rank, and power save as the necessary antecedents to the essential condition.

Two assertions, which can be made without the slightest fear of contradiction, may be put into juxtaposition in order to contrast the remedy proposed with the state of things it is desired to cure. First, that of all great nations the British Empire has most signally failed in its application of scientific knowledge and methods to its national problems; and, secondly, that in the British Empire there exists a body of skilled and hard-working scientific investigators second to none, and, even under the most disheartening conditions, actually enlarging the boundaries of natural knowledge in no mean degree. As the great schemes for rectifying matters crystallise into action, with the formation of a Department of Scientific and Industrial Research at home and concrete proposals for action, as in the Indian reorganisation suggested, more and more they seem to amount to this: The men who do the work, and against whom no fault is alleged, are to be deprived even of what little satisfaction and independence genuine scientific work for its own sake affords, and are to be put under the men against whose incompetence and lack of knowledge the whole uproar originally arose. In research, where, as the leading article in NATURE of February 19 so truly says, the man is everything, that man is to be put under men who brought an Empire, as rich in scientific talent and genius as any, perilously low. The remedy, surely, is to put the incompetent machine under the charge of competent men, not *vice versa*.

Our *soi-disant* scientific representatives seem still in the stage once lived through in our ancient universities, where it was at one time deemed politic that any scientific demand, if it were to pass, should be put up and seconded by well-known opponents of science, thus, on the chance of securing a temporary advance, permanently sacrificing the whole future. That we did not in 1914–19 repeat the medical horrors of the Boer War, when more died of pestilence than at the hands of the foe, is surely due to the emancipation in the interval of the Army medical services from non-qualified misdirection. That our food control during war-time was successful, even by comparison with that of more favourably situated belligerents, was because scientific men were from the first in charge of its scientific aspects—a rare condition, due probably to so many of them belonging to the profession that exacts due and proper respect for its members. Can one imagine young medical graduates, after a prolonged and serious university training, being sent up, as our scientific graduates were sent, hauling about gas cylinders with the rank of corporal? Can one imagine a director of a medical research association a foreign business man or manufacturer unknown to the research world? Can one imagine a proposal for State aid for medical research being dismissed by an unqualified person so ignorant of the history of scientific discovery as to deem it sufficient to dub the proposal as a "floating research" in order in his own eyes to condemn it? Neither can I imagine such happening in the scientific world if its leaders were equally alive.

Ordinary people, benevolent to science and unfamiliar with affairs, often wonder why scientific men are so powerless and peculiarly unable to protect themselves and to advance their subjects to a position commensurate with their national importance. The answer is to be found, I think, in the obsolete character of their so-called representative societies. Year after year in the chief of these the councils nominate and elect themselves without any reference to their members except for formal ratification. Through sheer lack of backbone and being out of contact with the body of their members, time and again they sacrifice interests vital to the continued existence of genuine scientific research. I do not wish to advocate for scientific investigators a close corporation keeping lynx-eyed vigil over their professional interests and seeking every opportunity to enlarge and consolidate them, identical with other learned professions; for the paramount interest of a scientific investigator should be his work, and his privileges, emoluments, and status are to be regarded merely as means necessary to secure opportunity and power *to do it*. That should be the test of these schemes, and not the further subordination of the men who do the work to the organisation attempting to get the work done. But unless they band together and take action, the rank and file of research workers throughout the Empire will not even be able to retain the miserable position they occupied before the war in the national life, and their interests will continue to be sacrificed to the ambitions and love of power of the few.

FREDERICK SODDY.

THE "Notes" columns of NATURE for February 19 contained a reference to a suggested conference between British botanists at home and overseas at which matters of common interest would be discussed. From some preliminary correspondence which had taken place in order to ascertain the feeling of our colleagues overseas as to the prospects of success of such a conference some interesting communications were received, especially from India, which bear on the subject of the organisation of scientific work. It was urged that this should form a subject for discussion in the event of a conference taking place, and it was evident that the writers were strongly opposed to a policy of centralisation. On the contrary, they were seeking greater freedom in their scientific work, and their communications hinted at irritating restrictions and disastrous results due to official interference—effects which would be much

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enhanced by such a scheme of centralisation as was indicated in the leading article in the same issue of NATURE. There may have been some waste of effort in the past, both at home and overseas, owing to insufficient co-operation between men of science working independently, but this is a matter for workers to set right among themselves, and will not be mended by an organisation conceived on the lines of a German military system. Further, it is unlikely that the best men will be attracted to work under such deadening conditions.

Care must be taken that public money is not wasted in scientific development, but the kind of official control suggested by a scheme of centralisation does not commend itself as an efficient waste-preventer. Grants of money to scientific societies or institutions might be administered by carefully selected boards of trustees, the scientific work being left to the unhampered initiative of the scientific staff under a head specially suited to the character of the work. The management of our Natural History Museum, a Government institution, is invested in trustees, who leave to the scientific staff the carrying out of the scientific work as effectively as funds and opportunity allow. Research work of the highest value to agriculture is being carried out at the Rothamsted Experimental Station, the original endowment of which has been generously supplemented by private munificence and by Government grants. Here also the management is vested in a small committee the members of which represent the various scientific sides of the work carried on.

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Gravitational Deflection of High-speed Particles.

THE investigation of the consequences of Einstein's law as regards the motion of a material particle moving through a gravitational field with a velocity comparable to that of light brings out some interesting and rather surprising effects. As Einstein's law is entirely kinematical, involving accelerations instead of forces, no account need be taken of variation of mass with velocity other than that contained in the law itself. Let m denote the mass of the attracting body (*i.e.* the sun) in astronomical units divided by the square of the velocity of light. Then the motion of a particle in the field produced by this body is determined by

$$\delta\int\sqrt{\left(1+2\frac{m}{r}\right)\left(dr^2+r^2d\theta^2\right)-\left(1-2\frac{m}{r}\right)c^2dt^2}=0,$$

the $r\theta$ plane being that of the orbit. From the Lagrangian equations corresponding to this Hamiltonian statement of the law, the energy relation

$$\frac{1}{2}\frac{d}{dt}(v^2)=-\frac{mc^2}{r^2}\left(1-4\frac{m}{r}\right)\dot{r}=3\frac{m}{r^2}v^2\dot{r}$$

is obtained. If the velocity of the moving particle is comparable to the velocity c of light, the second term in the parenthesis on the right-hand side may be omitted as negligible compared to the last term. The resulting approximate equation is easily integrated, leading to the expression

$$v^2=c^2\left\{a^2\left(1-6\frac{m}{r}\right)+2\frac{m}{r}\right\},$$

where a is the ratio of the velocity of the particle at infinity to that of light.

Consider a particle the velocity of which at infinity is negligibly small compared to that of light. Then the factor a is small, and the second term in the parenthesis which it multiplies may be omitted. This gives the energy equation of the Newtonian theory.

If, however, the particle has a high velocity, the omitted term becomes of importance. In fact, when the velocity is $1/\sqrt{3}c$, this term has the same value as the third term, but the opposite sign. Therefore, these two terms annul each other, and the velocity of the moving particle is unaffected *in magnitude* by the gravitational field. In other words, the *tangential* acceleration of the particle is zero throughout the course of its motion through the field. If it were headed directly for the attracting centre, it would move along in a straight line with constant speed just as if no field were present.

Next, consider a particle having a velocity at infinity greater than $1/\sqrt{3}c$. The velocity of this particle is actually decreased by the gravitational field. If it were aimed straight at the attracting mass, it would be slowed down just as if it were *repelled* with a force varying inversely with the square of the distance. If the velocity of the particle at infinity is equal to that of light, its velocity decreases as it approaches the centre of attraction in the same amount as that of a light-wave, for Einstein's theory makes no distinction between material particles and electromagnetic disturbances.

Consider a particle moving along the X axis with a high velocity v. Let the attracting mass m be on the Y axis, a distance R below the origin. Then the components of the particle's acceleration are

$$f_x=-\frac{mx}{r^3}\left(c^2-3v^2\right),$$

$$f_y=-\frac{m\mathrm{R}}{r^3}\left(c^2-v^2\right).$$

If the particle's velocity is greater than $1/\sqrt{3}c$, the tangential component f_x is positive, and the particle is slowed down as it approaches the centre of the field. The normal component f_y, however, causes the particle to be deflected towards the gravitating mass for all velocities less than c. This deflecting acceleration becomes less, however, as the velocity increases, and a particle moving with the velocity of light would travel through a gravitational field in a straight line. Its velocity, however, decreases as it approaches the gravitating centre, and then increases as it recedes from this point. For velocities close to that of light the deflection is given by

$$2\frac{m}{\mathrm{R}}\left(\frac{c^2-v^2}{v^2}\right).$$

The deflection suffered by a light-wave is of a nature quite different from that experienced by a material particle. A ray of light is not bent towards the sun by the latter's gravitational attraction, but the velocity of that portion of the wave-front closest to the sun is decreased more than that of the more remote portion. Therefore, the wave-front is swung round in exactly the same way as when light passes obliquely from a rarer to a denser refracting medium.

In conclusion, it may be noted that the two consequences of Einstein's law which are of great enough magnitude to be tested experimentally have been most conspicuously verified. The predicted shift of the Fraunhofer lines towards the red does not seem to be a necessary consequence either of Einstein's law or of the part of the theory on which this law is based, but rests on the very doubtful assumption that the system of a freely moving atom near the sun's surface is identical with that of a freely moving atom 93,000,000 miles away. If space-time had the same properties in

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